National Aeronautics and Space Administration

Ameliorating Non-linear Detector Effects in Weak Gravitational Lensing Measurements

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Project Objective:

The objective was to design and build an optical system for projecting well-known shapes onto various optical and near infrared (NIR) detectors. This system is part of an integrated plan to develop the capability to characterize, mitigate, and verify detector systematics that affect galaxy shape measurements. This is a crucial step in ensuring that detectors meet the strict requirements of future mission to measure **dark matter and dark energy** via subtle shape distortions induced by **weak gravitational lensing**.

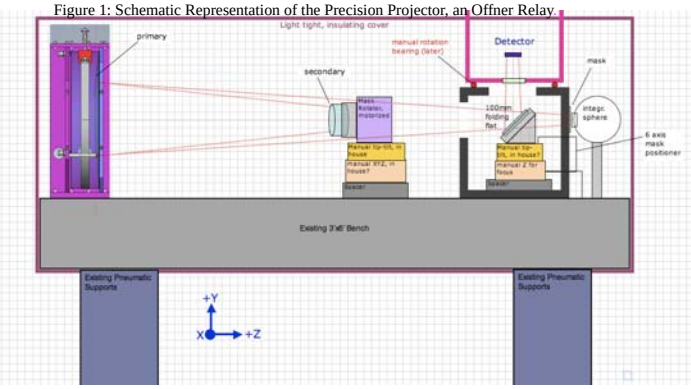
FY09 Results:

- Designed "Precision Projector" to meet demanding specification of future weak lensing missions
- Studied design trades between cost, point spread function (PSF) quality/uniformity, field of view, wavelength coverage, and ability to span focal ratio of proposed weak lensing missions
- Held mid-year design review with outside experts
- Revised design based on review results
- Procured or fabricated all necessary components: large λ/100 mirrors, optics mounts, precision multi-axis stages, illumination system, thermal controls, first set of masks
- Secured a thermally stable, clean laboratory space exclusively for this apparatus
- Began construction
- Implemented thermal control, verified 150mK p-p over 2 weeks.
- Designed calibration procedures for optical alignment in spite of undersampling
- Secured follow on funding

Benefits to NASA and JPL (or significance of results):

- Critical element in end-to-end detector verification effort at JPL/Caltech
- Positions JPL for business in future dark energy missions
  - NASA/DOE Joint Dark Energy Mission (JDEM)
  - ESA Cosmic Visions Euclid Mission
  - Follow on funding of $133k from DOE received to test p-channel CCDs from Lawrence Berkeley National Lab
  - JDEM project office funded simulations and associated detector characterization to asses sensitivity to detector effects ($400k)..
- Projector will be used to test photometric accuracy of detectors for All Sky Transit Observatory mission (ASTrO; Beichman PI).
- Rigorous design has made the Precision Projector useful beyond it's original intended scope

Figure 1: Schematic Representation of the Precision Projector, an Offner Relay



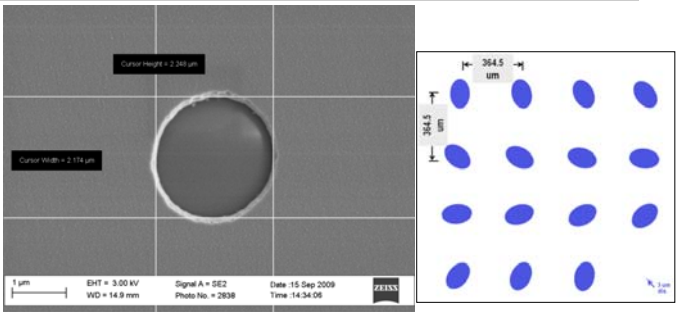
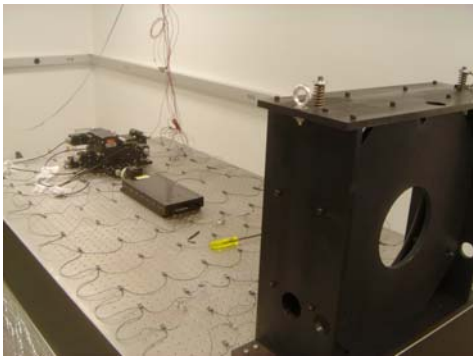


Figure 3: The left picture is an electron microscope view of one of the holes in our first set of masks confirming that manufacturing error < 60nm. The masks contain the shapes that will be projected onto the detectors. The right figure is a map with a range of "galaxy" orientations.

Figure 2: Partially assembled projector system, showing bench on vibration isolating stands, in dedicated HEPA filtered and thermally controlled dark room at Caltech's Cahill Laboratory. Lakeshore 340 temperature control (on shelf above bench) has been wired to 98 power resistors evenly distributed across the bench with 8 temperature sensors to provide fine thermal control. (Insulating covers have been removed.) The Thorlabs 6 axis flexure stage for the mask is seen in the foreground of the left picture, the 1um resolution translation stage in the middle of the bench is for secondary focus and the primary mirror cell which was designed and built in house is in the foreground of the right picture. The optics, mask, pupil rotator and detector are not installed.



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